complete investigation of the stability of a ship at angles considerably beyond those to which the metacentric height is a fair measure of the stiffness." He also speaks of the "stability of a ship up to 60° of inclination." This is a strange although common misuse of the term "stability." Stability only exists at a position of stable equilibrium, and what is really meant by the above-quoted sentence is not stability at large angles of inclination, but *righting force*.

The other paper upon stability, which describes a method of approximation to curves of stability from data for known ships, is interesting in showing how some of the elements of stability vary in a ship with the ratios of draught of water to depth, and depth to breadth; but we cannot regard it as likely to be of much value in practice. The approximations obtained by applying the method are only reliable when the form of the vessel for which the curve of stability is required, and that of the one which is being used for estimating it from, are so related to each other that any section of the one may be obtained by projection from the corresponding one of the other. Differences in form are excessively numerous—almost universal indeed—among ships; and small discrepancies of such a kind often affect stability to an important degree. When vessels are found to belong to what is defined in the paper as a "type-form," the method is applicable, but where no true type-form can be discovered for a particular ship—and this is what usually happens in practice—the only reliable and also the readiest mode of approximation to a curve of stability is to compute by means of Amsler's integrator the true length of a small number of ordinates of the curve.

There are other papers of interest in this volume which are amply deserving of perusal, though we have not space for referring in detail to them. We may note, however, as an indication of the active and enlightened interest taken by Scotch engineers in scientific teaching, that the President of the Institution of Engineers and Shipbuilders in Scotland—in referring at one of the meetings to the endowment of the John Elder Chair of Naval Architecture in Glasgow University, which is filled by Prof. F. Elgar—said that "the Council had agreed, and were morally bound, to support the institution of a lectureship in anticipation of a Chair of Naval Architecture in the University." Mr. Reid further stated that "the Council had agreed to continue the lectureship in connection with the Chair," and he wished it to be known that the original intention was still to be carried out. This is a strong practical proof of the earnestness and wise liberality of Scottish engineers in the matter of scientific and technical education, and it is a policy which cannot fail to largely benefit the district in time to come. It is also one indication, out of many, of the advantages which may confidently be looked for by engineers and scientific men as the natural outcome of such institutions as those we have referred to.

THE EGGS OF MONOTREMES

SPEAKING at the anniversary meeting of the Royal Society in November 1883, Prof. Huxley said:—"It certainly was high time that British science should deal with a problem of the profoundest zoological interest, the materials for the solution of which abound in, and are at the same time confined to, those territories of the Greater Britain which lie on the other side of the globe." These words had reference to the series of investigations which Mr. Caldwell—the first Balfour Student—had then gone to Australia to prosecute with regard to the embryology of the lowest Mammalian forms, the Monotremes and Marsupials.

Somewhat less than a year later, and whilst the British Association was holding its meetings in Montreal, Prof. Moseley, the President of the Biological Section, was enabled to communicate the following brief but suggestive message telegraphed from Australia:—"Caldwell finds Monotremes oviparous; ovum meroblastic." Brief as was the message, it yet, as Prof. Moseley said, contained the most important scientific news which had been communicated to the Association in Canada.

Zoologists will now look forward with deep interest to the publication of Mr. Caldwell's more detailed account of his recent investigations, which have apparently enabled him to confirm so fully what has before been suspected, but never actually proved to be the case.

That Monotremes are oviparous has been maintained by various naturalists for now some sixty years: but up till the present time no sufficient evidence has been brought forward to place the matter beyond dispute, the chief difficulty in elucidating the problem lying in the fact that the two curious groups of animals which alone are placed in the Monotremata inhabit exclusively the Australian region, and hence have been but little studied in their natural habitat.

Though they are closely allied, yet the Ornithorhynchus and Echidna differ markedly from each other in external appearance—the one being adapted to the water, having its feet webbed, and its muzzle of that peculiar shape which has earned for it the name of Duck-billed Platypus, whilst the other is essentially a land animal, feeding on ants which it licks up by means of a long flexible tongue, and having its body covered with sharp spines, much as a hedgehog.

The question of how these animals reared their young, and in what condition the latter were born, has long been a matter of much dispute, and for information we are principally indebted to the memoirs of Home, Meckel, Geoffroy St. Hilaire, and perhaps most of all to Owen; whilst from time to time short notices are to be found in the *Proceedings* of the Zoological Society and the *Journal* of the Linnean Society.

In 1829 Geoffroy St. Hilaire laid a communication before the Royal Academy of Sciences in Paris, entitled "Considérations sur les œufs d'Ornithorinque formant de nouveaux documens pour la question de la classification des Monotrêmes."[1] Herein he stated his opinion that the Monotremes could no longer be admitted amongst the mammals, nor could they be classified with either birds, or reptiles, or fishes, but they must, though including only two groups of animals, be formed into a distinct fifth class among the Vertebrata, which would hence be divided, according to him, into Mammals, Monotremes, Birds, Reptiles, and Fishes.[2] The most interesting part of his paper, from our present point of view, however, consists of a letter which he quotes in full from Prof. Robert E. Grant of London, who describes in some detail the finding by a certain Mr. Holmes, whilst shooting on the banks of the River Hawksburgh in Australia, of a nest of eggs laid by an Ornithorhynchus; the animal was seen to hasten away from a sandy bank and plunge into the water. Examination of the bank led to the discovery of a small burrow, in which, on a rude nest made of twigs, were deposited nine eggs of a peculiar shape and size, which rendered them clearly distinguishable from those of any bird. The eggs, he says, are remarkable "par une forme régulière sphéroïdale oblongue, par une égale largeur à chaque bout; ils ont (mesure anglaise), en longeur de pouce, $1\frac{3}{8}$, et en largeur $0\frac{6}{8}$; la coquille est mince, fragile, légèrement transparente, et d'une couleur uniforme d'un blanc mat; sa surface extérieure, vue à la loupe, présente une texture d'un réseau admirablement réticulé; la matière calcaire a produit les parois blanches de ses innombrable et très-petites cellules, ce qui n'empêche pas que la surface n'en demeure à peu près polie.

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[1] *Annales des Sciences Naturelles*, t. xviii. p. 162; also *Bulletin de la Société Philomathique*, t. viii. p. 95.

[2] The same idea is to be found also in Lamarck, *Philosophie Zoologique*, t. i. p. 145. Lamarck adds, further, "Ce ne sont point des mammifères; car ils sont sans mamelles, et très-vraisemblablement ovipares."

Un des œufs était cassé, et j'en ai examiné la surface interne, laquelle m'a paru être aussi formée par un dépôt de très-petits grains de la matière calcaire.” He further states that the dimensions and form of these eggs remind him of those of many of the Saurian reptiles and Ophidians; whilst Jarrel, who examined them, came to the conclusion that they differed as much from the eggs of birds as from those of reptiles.

Fig. 1 is copied from a drawing which accompanies the paper of Geoffroy St. Hilaire, and represents its actual size and form.

Of the nine eggs which were discovered in the nest four were brought to England, and of these two found their way to the Manchester Museum, where, Prof. Williamson has kindly informed me—whilst he was curator, from 1835 to 1838—he distinctly remembers their being placed and labelled as “eggs of Duck-billed Platypus.”

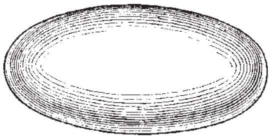

FIG. 1.

In 1826 Meckel, of Halle, had published a monograph on *Ornithorhynchus paradoxus* (Leipzig, 1826), wherein he announced the discovery of mammary glands, rudimentary in condition, but still undoubtedly present, and serving for the nutrition of the young; Geoffroy St. Hilaire, who, as before said, was strongly of opinion that the Monotremes could not be included amongst the Mammalia, suggested that the nature of these glands had not been sufficiently studied, and that instead of being mammary they were very probably analogous to those spread out on the flanks of aquatic reptiles, and which served to lubricate the skin; if this were not the case, he further suggested a comparison between them and certain odoriferous glands existing in the neighbourhood of the mammary glands in shrews.[1]

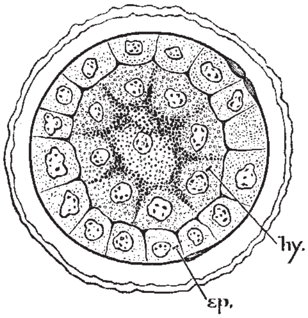

FIG. 2.

To these criticisms Meckel urged in reply the strong argument that they were only known to exist in female Monotremes, the males possessing no such structure, and later still Owen published his account of the “Mammary Glands of *Ornithorhynchus paradoxus*” (*Phil. Trans.* 1832). In this paper also he quotes the following passage from Meckel (“*Ornithorhynchi paradoxi* Anatome,” p. 58):—“The difference between the bringing forth of living young and of eggs is really very small, and by no means of an essential nature: birds have accidentally hatched the eggs within the abdomen, and so produced a living fœtus—an occurrence which has been induced by direct experiment; and lastly the generation of the Marsupial animals is very similar to the oviparous mode.” Meckel, Owen says, deems it “very probable that as the Ornithorhynchus approaches still nearer than the Marsupials to birds and reptiles, its mode of generation may be in a proportionate degree analogous.”

Somewhat later Owen published an account of an Ornithorhynchus fœtus,[1] which measured only two inches in length. After describing its external appearance he says, “On the middle line of the upper mandible, and a little anterior to the nostrils, there is a minute fleshy eminence lodged in a slight depression. In the smaller specimen this is surrounded by a discontinuous margin of the *epidermis*, with which substance therefore, and probably (from the circumstance of its being shed) thickened or horny, the caruncle had been covered. It is a structure of which the upper mandible of the adult presents no trace, and is obviously analogous to the horny knob which is observed on the upper mandible in the fœtus of some *birds*. I do not, however, conceive that this structure is necessarily indicative of the mandible's having been applied, under the same circumstances, to overcome a resistance of precisely the same kind as that for which it is designed in the young *birds* which possess it. The shell-breaking knob is found in only a part of the class, and although the similar caruncle in the Ornithorhynchus affords a curious additional affinity to the *Aves*, yet as all the known history of the ovum points strongly to its ovo-viviparous development (see also *Phil. Trans.*, 1834, p. 555), the balance of evidence is still in favour of this theory.”

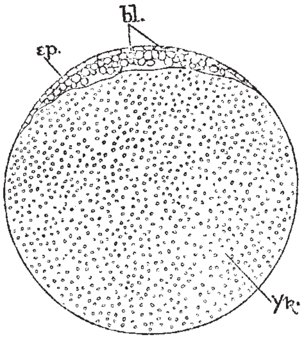

FIG. 3.

Later still (*Phil. Trans.*, 1865, p. 671) he published a paper on the “Marsupial pouches, mammary glands, and mammary fœtus of the *Echidna hystrix*,” wherein he proved that the same caruncle was present in the Echidna fœtus, and further that this was carried about by the mother in a pouch (two being present in each individual, one on either side the middle ventral line), into which opened the mammary glands.

Owen adheres firmly to the opinion that the Monotremes are ovo-viviparous, in which opinion he is supported by the evidence of, amongst others, Sir E. Home (*Phil. Trans.*, 1802, p. 67), whose account is probably the earliest notice of any detail, which was published in England with regard to the internal anatomy of Ornithorhynchus.[2] Home says at the close of his paper, “this animal having no nipples and no regularly formed uterus, led me to examine the female organs in birds to see if there was any analogy between the oviducts in any of that class and the two membranous uteri of this animal;

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[1] *Proc. Zool. Soc.*, 1833, pp. 28 and 91; also, “Memoir on the Abdominal Glands of Ornithorhynchus, falsely presumed to be mammary, but which secrete, not milk, but mucus, destined for the first nutriment of the young when newly hatched,” *Gazette Médicale*, February 18, 1833; also, *Annales des Sciences Naturelles*, tom. lx. p. 457.

[1] *Trans. Zool. Soc.*, vol. i. p. 222; also *Proc. Zool. Soc.*, 1834, p. 43.

[2] For one of the earliest figures, see Shaw's *Naturalist's Miscellany*, vol. lx. 1799, and for figure of Echidna *vide op. cit.* vol. iii. 1792, under name of *Myrmecophaga aculeata*. Shaw says of Echidna, “It is also a most striking instance of that beautiful gradation so frequently seen in Nature, by which creatures of one tribe or genus approach to those of a very different one. It forms a connecting link between the very distant genera of Hystrix and Myrmecophaga; having the external aspect of the one with the mouth and peculiar generic characters of the other.”

but none could be observed, nor would it be easy to explain how an egg could lie in the vagina to receive its shell, as the urine from the bladder must pass directly over it. Finding they had no resemblance to the oviducts in birds, I was led to compare them with the uteri of those lizards which form an egg that is afterwards deposited in a cavity corresponding to the uterus of other animals where it is hatched; which lizards may be therefore called ovo-viviparous, and I find a very close resemblance between them."

There has been, however, a certain amount of direct evidence brought forward beyond that which has been quoted from Geoffroy St. Hilaire's paper to prove that Monotremes are really oviparous, notwithstanding the fact that they nourish their young by means of mammary glands.

Thus a Dr. Nicholson (*Phil. Trans.*, 1865, p. 683), writing to Owen in 1865, informs him that a Platypus had been captured by workmen on the banks of the River Goulburn in Victoria, and had been placed for a night by the gold-receiver of the district, to whom it had been handed over, in a wooden case, and that whilst in confinement it had laid two eggs—white and soft, with no calcareous covering, and about the size of a crow's egg. Dr. Nicholson does not, however, appear to have taken the trouble to examine the eggs at all carefully, and his evidence is rejected by Owen as certainly insufficient to make him doubt that the Monotremes are ovo-viviparous.

Earlier still in Messrs. Lesson and Garnot's "Voyage de la Coquille" (*Zool. Journal*, vol. v.), it is stated that the colonists assured the travellers that Ornithorhynchus was oviparous, whilst a Mr. Murdoch, superintendent of the farms on Emu Plains, said that he himself had seen the eggs, that they were two in number, and the size of a hen's egg.

Again, Dr. Weatherhead (*Proc. Zool. Soc.*, 1832, p. 145) read, before the Zoological Society in 1832, extracts from a letter received by himself from Lieut. Maule in New South Wales, wherein the latter describes in some detail the finding and unearthing of an Ornithorhynchus burrow. The entrance to the latter, he says, is beneath the water, though, after some little distance, the passage rises, and, after a few yards have been traversed, it "branches into two others, which, describing each a circular course to the right and left, unite again in the nest itself, which is a roomy excavation lined with leaves and moss, and situated seldom more than twelve yards from the water or less than two feet below the surface of the earth: several of these nests were with difficulty discovered. No eggs were found in a perfect state, but pieces of a substance resembling egg-shell were picked out of the debris of the nest. In the insides of several Platypi which were shot were found eggs of the size of a musket-ball and downwards, imperfectly formed however, *i.e.* without the hard outer shell, which prevented their preservation."

Dr. Bennett also (*Proc. Zool. Soc.*, 1859, p. 213) investigated the structure of the Monotremes and examined the nest of Platypus, but failed to find traces of eggs.

Lastly, Mr. Patrick Hill, surgeon in the Royal Navy, published in *Trans. Linn. Soc.*, xiii. p. 621, information which had been brought to his notice concerning the Monotremes whilst studying their nature and habits in the district around Sydney. A female specimen was brought to him which had been taken directly from its nest, but which died very soon after being placed in confinement. On opening the body he discovered in the left ovary a round yellow ovum about the size of a small pea and two of smaller size, whilst no trace of ovisac was to be found in the right ovary;[1] but beyond his own investigations he brings forward the evidence of a certain Cookoogong, chief of the Boorah-Boorah tribes, who, as is quaintly remarked in Geoffroy St. Hilaire's article, "ne manquait ni de lumière ni de moralité." This native chief stated that it was a fact well known to their tribe that the animal lays two eggs, about the size, shape, and colour of those of a hen, and that the female sits a considerable time on her eggs in a nest which is always found among the reeds on the surface of the water; the native name for the Platypus, he added, was Mullingong.

The most important part of Mr. Caldwell's communication to the British Association was, however, contained in the two words "ovum meroblastic"; in other words, the ovum of a Monotreme contains, relatively to the pure protoplasm out of which the tissues of the animal will be formed, so much food-yelk that, when segmentation takes place, it is impossible for the egg to segment as a whole, and therefore the two kinds of protoplasm separate, and we find that the Monotreme embryo possesses a yelk-sac, by the gradual absorption of the contained material of which it is nourished during the early stages of development.

The presence of so large an amount of food-yelk thus renders it unnecessary that during this period the tissues of the embryo should enter into such a close relation with the maternal ones as is found to obtain in the rest of the Mammalia, though even amongst the higher members of the latter there are certain signs which point to a former period in their phylogenetic history when they also were possessed of a yelk-sac.

Figs. 2 and 3 represent respectively examples of holoblastic and meroblastic ova at very early stages, the one being that of a rabbit, the other that of a Sauropsidan, and it is to the latter that the ovum of Monotremes bears a close resemblance.

In both cases it is interesting, however, to observe that a structure is eventually formed known in birds and reptiles as the yelk-sac and in most mammals as the umbilical vesicle, the two being really homologous with each other.

Now that Mr. Caldwell has shown that in the lowest mammals a yelk-sac is present containing food-yelk instead of an umbilical vesicle as in the higher forms, it may be affirmed that the curious stages in the development of most Mammalia which result in the pinching off of the embryo and the formation of an umbilical vesicle are indications still remaining of the time when these animals were nourished during early stages, not directly by a close union with the maternal tissues, but by means of yelk-sacs: it affords evidence, in fact, that their ancestors were not viviparous, but oviparous, just as are the lowest mammals now known to us.

During late years various theories have been held concerning the origin of mammals: Balfour formed a hypothetical group—the Pentadactyloidei—in which he supposed the pentadactyle limb characteristic of all the higher vertebrates to have been established: from this he derives two groups—the one including the present existing Amphibia, the other being a hypothetical and somewhat generalised group, from which, though along divergent lines, were developed both Mammalia and Sauropsida. Thus, according to him, the two latter were branches from one common stem, but the Sauropsida could not be considered as the ancestor of the Mammalia.

Other scientific men have held that mammals were derived from Amphibia-like ancestors: with the present Amphibia they were supposed to agree in the presence of a holoblastic ovum, and in the important fact that in both groups two occipital condyles are present, whilst only one is typically found in the Reptilia.

It is interesting to notice that Cope has described, amongst the numerous extinct forms of reptiles which he has brought to light during the past few years, one, called by him the Theromorpha (*Proc. Am. Phil. Soc.*, vol. xix.

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[1] See also Owen, "Anat. of Vert.," vol. iii. p. 676; also *Proc. Zool Soc.*, 1834, p. 143.

p. 38), which he regards as intermediate between Reptilia and Mammalia. He says:—"The order Theromorpha approximates to the Mammalia more closely than any other division of Reptilia. This approximation is seen in the scapular arch and humerus, which nearly resemble those of the Monotremata, especially Echidna; and in the pelvic arch, which Owen has shown in the sub-order Anomodontia to resemble that of the mammals, and, as I have shown, especially that of Echidna. The tarsus is also more mammalian than in any other division of reptiles. In the genus Dimetrodon the coracoid is smaller than the epicoracoid, as in Monotremes. The pubis has the foramen for the internal femoral artery." Cope also appears to have found in the Theromorpha a spur attached to the hind foot, just as in the males of Monotremata.

In the skeletons of the latter, on the other hand, we find several prominent features in which, whilst they differ from the typical mammalian forms, they approximate more or less closely to the reptiles, whilst finally Mr. Caldwell's discovery with regard to the nature of the ovum has shown that Mammalia and Sauropsida are closely allied to each other—more intimately than has generally been allowed by naturalists.

In Monotremes we find, as it were, intermediate animals possessing the attributes of two classes: whilst on the one hand they have developed mammary glands, the distinctive feature of the higher group, on the other they lack that structure whereby the typical mammalian embryo receives nourishment before birth; and in correlation with this we find them agreeing with the lower class in the possession of a yelk-sac, whilst the contained food-yelk causes the ovum to assume the meroblastic type.

We may thus trace the line of descent through the Sauropsida directly to the Monotremes (doubtless through forms now extinct, as the Theromorpha of Cope); from these to Marsupials, which are indeed viviparous, but whose ova still possess a large yelk-sac, and whose embryos, as Mr. Caldwell (*Q.J.M.S.* October 1884) has just shown, enter into no close vascular connection with the maternal tissues; and from these to the higher mammals, whose much specialised structures for fœtal development differ now so widely from those of the lower vertebrates.

W. BALDWIN SPENCER

NOTES

LAST Thursday (December 4) the Chemical and Physical Society of University College, London, gave a scientific *soirée* in connection with the University College Society. Prof. T. G. Bonney delivered the annual address, and took as his subject "Serpentine Rock and its Origin." The lecture was illustrated by Wright and Newton's new oxy-hydrogen microscope. During the evening demonstrations were given on "Radiant Matter" by Mr. Rose Innes, "Absorption Spectra" by Mr. Schunck, and "Ozone" by Mr. E. E. Craves, in various parts of the building. In the library were exhibited by several gentlemen and manufacturers new scientific apparatus and chemical compounds. The physical and chemical laboratories were thrown open to visitors, and in them were shown new forms of apparatus for research. The meeting was numerously attended, and the committee are to be congratulated on the success of the evening.

THE ordinary general meeting of the members of the Parkes Museum was held on Thursday, December 4, Capt. Douglas Galton, C.B., F.R.S., in the chair. The meeting was held to consider the report of the Council for the tenth year and to elect officers. The report set forth the work done in connection with the Museum during the past year, which had included lectures by the Council of the Sanitary Assurance Association in addition to those arranged by the Council of the Museum. The accounts showed that there was urgent need for increased subscriptions if the Museum was to be continued, for the small invested capital had had to be made use of this year to meet the current expenses. The report was adopted on the motion of the Chairman, seconded by Mr. Rogers Field. Mr. Mark H. Judge, then proposed "That the report be printed for circulation, with a detailed statement of the financial position of the Museum, and that a special meeting of the members be convened within two months to consider the same." This was seconded by Mr. E. C. Robins, and carried unanimously. Sir R. Lloyd Lindsay, Prof. J. Marshall, F.R.S., and Mr. Alfred Waterhouse, A.R.A., were elected Vice-Presidents. Six new Members of Council were elected, and the meeting closed with a vote of thanks to the Chairman, proposed by Dr. J. C. Steele of Guy's Hospital.

WE have before us a most satisfactory report of the Manchester Public Free Libraries for 1883–84, showing increase everywhere. More than one and a quarter million of issues have been made to two and a half million of visitors to the libraries. Of these the boys have been provided with additional reading-rooms to themselves, which are reported as crowded every evening; the increased Sunday issues of books also are noted as being specially made to boys, and it cannot be doubted that a taste for reading thus early implanted will save them from half the temptations to which idle youth is subjected. While nearly 10,000 new books have been purchased, more than 10,000 have been started in new harness for fresh toil by the bookbinder; and few items can speak better of "something accomplished, something done," than 3325 volumes withdrawn from circulation, simply worn out. At one branch a new catalogue published, at another one preparing, and at a third two supplementary lists issued, keep the value and the availability of the books at the highest point.

AT the meeting of the Geologists' Association last Friday, Mr. R. Meldola gave a preliminary account of his investigation of the East Anglian earthquake of April 22, 1884, with special reference to the geology of the question. The extreme limits of the recorded disturbance were Brigg in Lincolnshire, Altrincham in Cheshire, Worcester, Bristol, Street (Somersetshire), Boulogne, and Ostend, giving in round numbers an area of 50,000 square miles. The focus of the disturbance appears to have been beneath the earth near the villages of Abberton and Peldon, between Colchester and Mersea Island, and there seems to have been total reflection of the shock at Wivenhoe on the River Colne, the tract of country to the north-east of this village, where great damage was sustained, being in "seismic shadow." The area of structural damage comprised about fifty or sixty square miles, the main axis being along a line five miles in length and extending in a S.W.–N.E. direction from Peldon to Wivenhoe. The evidence showing the propagation of the shock along the older rocks had been carefully considered, and the conclusion had been arrived at that such a spreading of the shock towards the west, north-west, south-west, and south-east had actually taken place, an additional argument in favour of the extension of the Palæozoic rocks beneath the south-east of England, as first suggested by the late Godwin-Austen in 1855, being thus furnished. It was pointed out that this extension of the disturbance along the older rocks was of a purely dynamical character, depending simply upon the superior elasticity of these formations. One phase of earthquake movement which the present disturbance appears to have revealed with special distinctness was the tendency of the shock to make itself felt along free margins such as coast-lines, river-valleys, lines of outcrop, &c. The general conclusion respecting the distribution of earthquakes in this country which the present investigation